

UNITED STATES AIR FORCE  
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EFFECT OF LOWER BODY  
NEGATIVE PRESSURE ON MITRAL  
VALVE MOVEMENT

Sandra Osswald  
Victor A. Convertino  
F. Andrew Gaffney

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Flight Stress Protection Division  
Physiology Research Branch  
2507 Kennedy Circle  
Brooks AFB, TX  
78235-5117

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13. ABSTRACT (Maximum 200 words) This study was designed to investigate the hypothesis that normal mitral valves will prolapse and/or regurgitate in some individuals when their left ventricular volume is reduced with lower body negative pressure (LBNP). The effect of ventricular volume changes on normal mitral valves is not well understood, however, a few studies have suggested that dehydration may cause normal mitral valves to prolapse. Ten men and ten women with normal cardiac findings underwent serial echocardiography with color-flow Doppler and progressive LBNP to -50mmHg from baseline. The data from two subjects (both women) could not be used due to technical difficulties. Of the 18 subjects, 10 had some degrees of mitral regurgitation (MR) at any stage of LBNP. The maximum severity from any of the subjects was mild MR. Five individuals had MR in the pre-LBNP period, but none of these progressed to more significant MR. Five individuals did not have MR in the pre-LBNP period and 4/5 developed trace/mild MR during LBNP. However, the degree of MR during LBNP was not progressive with successive LBNP stages. Although four individuals had anterior leaflet bowing in the apical 4-chamber view during LBNP, these findings alone were not diagnostic of MVP. Conclusions: LBNP is a graded, quickly reversible method of decreasing left ventricular volume in individuals. Further study into volemic state and perhaps individuals' body habitus will help determine the extent to which normal mitral valves may prolapse.				
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## INTRODUCTION

The diagnostic criteria for Mitral Valve Prolapse (MVP) has varied greatly over the last 20 years, with study and improved technology. However, controversies still exist especially in those with normal appearing valves that prolapse and those with varying cardiac auscultation and echocardiogram findings. Prolapse in an otherwise normal valve may be 'functional' and only related to the hemodynamic state of the individual as opposed to those that appear thickened and myxomatous. Certainly maneuvers which decrease left ventricular volume in individuals with MVP can increase the degree of prolapse. Additional studies have examined echocardiographic signs of MVP in mildly dehydrated individuals who had prior normal cardiac findings. Not only may it be possible to induce MVP with mild dehydration, but also changes may resolve with rehydration. These studies suggest that to avoid over diagnosis of MVP on the basis of exam or echocardiographic findings alone, one should take the individuals hydration state into account. Studies have already shown that individuals with MVP but an otherwise normal mitral valve appear to have less risk of significant complications on long-term follow up. This evidence suggests that complications are associated more often with true pathology and myxomatous degeneration of the mitral valve rather than normal appearing mitral valves.

Our study intended to determine if normal mitral valves could be made to prolapse and/or regurgitate in some individuals by lowering left ventricular volume. But, instead of using fasting or diuretics, we used Lower Body Negative Pressure (LBNP), a tool that provides quickly reversible changes in volume distribution. We elected to study the effects in both men and women.

## METHODS

*Study population.* After approval from the human use committee was obtained, volunteers from the general population, between 18-60 yrs of age were selected for the study. Screening was done by interview, cardiac physical examinations and cardiac echocardiograms. If subjects satisfied the requirements of a good quality echocardiographic image and had no evidence of significant cardiac history, abnormal cardiac examination, MVP or more than mild MR by echocardiography, they were invited to participate. A total of ten men and ten women were selected sequentially for the project.

*Study design.* A baseline history, cardiac physical examination and baseline echocardiography were performed on each subject. Initial examination included height, weight, blood pressure, heart rate (both supine and standing) and cardiac auscultation. The study was then performed in a single session. On the day of testing, the individual was placed in the LBNP chamber in the left lateral decubitus position at 30 degrees tilt. A baseline echocardiogram was performed by the Hewlett Packard Sonos 2000 system and included mitral valve imaging in the parasternal long-axis, parasternal short-axis, and apical four-chamber views. Color-flow Doppler was used to assess mitral regurgitation. Echocardiography was then repeated at each level of LBNP and after testing.

Following baseline data collection of blood pressure, heart rate and echocardiographic imaging, decompression of the LBNP device was initiated to -10mmHg from baseline for 5 minutes, followed by 10mmHg increments every 5 minutes until test termination. Termination of the LBNP protocol was determined by any one or combination of the following criteria: a) completion of 5 minutes at -50mmHg from baseline b) onset of presyncopal symptoms such as gray-out c) a precipitous fall in SBP greater than 15 mmHg, and/or a sudden bradycardia greater than 15bpm between adjacent 1 minute measurements d) progressive diminution of

SBP below 70mmHg or e) voluntary subject termination due to discomfort such as sweating, nausea, or dizziness. Total LBNP subject time was limited to no greater than 90 minutes. Continuous blood pressure and pulse monitoring was conducted throughout the entire experiment via the Finapres finger cuff blood pressure cuff monitoring device which provided beat by beat systolic and diastolic blood pressures and heart rates. The Colins automatic blood pressure cuff also made standard blood pressure and pulse determinations at the 2nd and 4th minute of each stage.

*Review of echocardiograms.* Measurements of the left ventricular end-diastolic (LVEDD), end-systolic, and left atrial dimensions were taken from images after American Society of Echocardiography standards. Two-dimensional (2-D) echocardiographic tapes were reviewed by an independent cardiologist.

*Analysis of mitral valve motion.* MVP in this study was defined as superior systolic displacement of mitral leaflets with coaptation point at or superior to the annular plane in the 2-D parasternal long-axis view. Mitral regurgitation was documented by Doppler echocardiography.

## RESULTS

*General data.* Of the 21 screened subjects, 20 satisfied the selection criteria and were asked to participate in the study. The one individual excluded had a mildly thickened mitral valve with moderate pansystolic MR. The data from two subjects, two women, could not be used due to technical difficulties. Thus data analysis was performed on 18 individuals, 10 men and 8 women. Ages ranged from 21 - 55 yrs with an average of 35.4 yrs for the group, 37.2 for males, 33.1 for the females. Further general demographic information on the individuals can be seen in Table 1.

*LBNP protocol measurement summary.* All 18 subjects were able to tolerate LBNP to -40mmHg from baseline, however, only 14/18 subjects tolerated the full data collection at the stage -50mmHg from baseline due to symptoms of lightheadedness or nausea. No individuals experienced syncope. All subjects had progressive diminution of their left atrial and left ventricular sizes with progressive levels of LBNP that reversed with termination of LBNP pressure.

*Echocardiographic responses to LBNP.* Mean  $\pm$  SE values for hemodynamic responses during LBNP for each of the subject groups are presented in Table 2. Of the 18 subjects, 10 had some degree of MR at any stage. The maximal severity of MR from any of the subjects was mild. Five of the 10 had MR in the pre-LBNP baseline period. None of these progressed to more significant MR. One subject had trace MR only at baseline and one had only trace MR during the post-LBNP period. Five of the 10 had no MR in the pre-LBNP baseline period and four of these developed trace or mild MR during LBNP. However, these four were not progressive with each successive level of LBNP. No subjects had diagnostic MVP before or during the study. Four had anterior leaflet bowing in the apical 4-chamber view only during LBNP, but did not show progression. There was not good agreement between those with trace MR and those with MVP. In summary, there was no clear progression of MR or diagnostic MVP with progressive levels of LBNP.

## DISCUSSION

This is one of the first studies to utilize serial echocardiography with color-flow Doppler under conditions of LBNP to demonstrate the physiologic effects of lowering left ventricular volume on normal mitral valves. The technique of LBNP produces changes in the size of the left atrium and left ventricle and decline of cardiac output as significantly as other studies that have used diuretics, but in a more quickly reversible fashion.

In the present study, only suggestive bowing in the 4-chamber view alone was seen, no individuals demonstrated diagnostic prolapse by echocardiography with LBNP. There was also no progression of MVP or MR with progressive levels of LBNP. The relative lack of findings can be attributed to many different causes. The study sample was small. The selection of subjects did not involve height and weight pre-selection criteria to study asthenic individuals in particular. In addition, the higher levels of LBNP made it more difficult to visualize the exact positioning of the mitral valve leaflets with the decreasing size of the LA and LV chambers. Another possibility may be that volemic distribution alone is not as important as volemic state in mitral valve movement and further study should be performed with the two factors considered concomitantly. In summary, this study was able to use LBNP to decrease left ventricular volume reliably and reversibly. Testing with larger numbers of individuals may determine to what extent mitral valves may move in normal subjects with dehydration, how often MVP may occur and what factors may predispose an individual to do so.

Table 1: Summary demographic information

	Group	Men	Women
N	18	10	8
Mean Height (in)	67.6 $\pm$ 1.0	69.6 $\pm$ 1.2	65.1 $\pm$ 1.3
Mean Weight (lbs.)	158.1 $\pm$ 6.5	171.1 $\pm$ 6.6	141.9 $\pm$ 9.5
Mean BSA (m <sup>2</sup> )	1.84 $\pm$ .05	1.95 $\pm$ .05	1.71 $\pm$ .07

Values are mean  $\pm$  1SE

Table 2: Summary of study data measurements through LBNP protocol

LBNP (mmHg)	Avg DBP (mmHg)	Avg SBP (mmHg)	HR beats/min	LA (cm)	LVIDD (cm)	LVIDS (cm)
Baseline	87 $\pm$ 3	131 $\pm$ 4	63 $\pm$ 2	3.07 $\pm$ .10	4.52 $\pm$ .11	3.03 $\pm$ .09
- 10	88 $\pm$ 3	132 $\pm$ 4	68 $\pm$ 2	2.87 $\pm$ .10	4.32 $\pm$ .08	2.93 $\pm$ .08
- 20	87 $\pm$ 3	128 $\pm$ 3	70 $\pm$ 2	2.66 $\pm$ .09	4.10 $\pm$ .07	2.84 $\pm$ .07
- 30	87 $\pm$ 4	129 $\pm$ 3	74 $\pm$ 2	2.45 $\pm$ .10	3.88 $\pm$ .06	2.74 $\pm$ .09
- 40	90 $\pm$ 2	131 $\pm$ 3	79 $\pm$ 2	2.33 $\pm$ .09	3.75 $\pm$ .09	2.62 $\pm$ .09
- 50	93 $\pm$ 3	126 $\pm$ 2	86 $\pm$ 4	2.24 $\pm$ .10	3.66 $\pm$ .15	2.66 $\pm$ .12
0	91 $\pm$ 2	135 $\pm$ 3	64 $\pm$ 3	3.02 $\pm$ .11	4.46 $\pm$ .12	2.94 $\pm$ .10

Values are mean  $\pm$  1SE; DBP, diastolic blood pressure; SBP, systolic blood pressure; HR, heart rate; LA, left atrial dimension; LVIDD, left ventricular inner diastolic dimension; LVIDS, left ventricular inner systolic dimension